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Chapter 4

Importance and Ranking Evaluation of Cost Overrun Factors for Oil Transmission Pipeline Projects

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Additional information is available at the end of the chapter

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Abstract

Over the recent years, the cost escalation in oil pipeline projects in Iran has been inevitable due to the political and economic conditions. On the other hand, due to Iran's 20-year vision plan, several projects and plans have been defined by National Iranian Oil Company (NIOC); therefore, to achieve the vision plan's goal and deliver the projects on-budget, identification of the cost overrun causes is the first step. In this research, a list of important cost overrun factors in oil pipeline projects was extracted after a detailed literature review, study the executed projects document, semistructured interview, and a questionnaire survey among clients, consultants, and contractors who are involved in such projects. The results show that the political and economic sanctions, rise in the price of material, delay in payments, unrealistic price proposal to win the tender, inflation, change in orders/extra works, type of bidding award, delay by vendors/suppliers, slow speed in obtaining permits/massive bureaucracy, and unrealistic time and cost estimation are ranked in the top ten cost overrun factors.

Keywords: project management, project delay, cost overrun, oil transmission pipeline

1. Introduction

Being a member of the Organization of Petroleum Exporting Countries, Iran ranks fourth in the world's oil reserves with total oil reserves of 154 billion barrels which amount constitutes 10 percent of the world's oil reserves and over 12 percent of the existing oil reserves of the OPEC (Organization of the Petroleum Exporting Countries). Iran also has signed agreements in the format of Swap with Azerbaijan, Kazakhstan, and Turkmenistan since 1997 that in this case, transmission pipelines play an important role. These instances are indicative of the importance of the oil industry in the economic sector and hence the growth and development of Iran. According

to the twenty-year vision plan of the oil industry, Iran plans to keep the second rank of oil producer within the OPEC and supply over 12% of the world's oil production by the end of the 2025. The share of the increase in the domestic demands by the year 2025 should be considered [1]. Therefore, in order to achieve these goals, the National Iranian Oil Company (NIOC) has defined several projects and plans in which some have been completed, a number are at hand and some have not yet been commenced. But the point worthy of this is that based upon the existing reports (project progress reports, coordination minutes of meetings, and the NIOC publications), most of the projects are facing delay and cost overrun as compared to the amount forecasted. Project finishing on time and absence of cost overruns are considered the most critical factors in projects success. According to the PMBOK (Project Management Body of Knowledge) 5th edition [2], project is successful if it achieves the triple objective outcome of within time, scope, and quality. Also many researchers have been trying to discover which factors lead to project success, according to their research, most of them imply that cost, time, and quality have become inextricably linked with measuring the success of project [3–6]. Unfortunately, due to various reasons, many projects experience time and cost overrun. Delay of project in any type, such as excusable/concurrent/compensable and critical, leads to qualitative and quantitative cost escalation. The quantitative costs consist of such cost as the lost profit, escalation of costs, and the cost of the interest of the capital spent, which are easily calculable through principles as engineering economics; while qualitative costs are not visible and cover such instances as the loss of the company's creditworthiness, losing the competitive market and as well the loss caused due to the reduction in the government revenues. This is especially true in Iran due to the resistive economy policy that is proposed by the government. These are indicative of the importance of identification the factors having impacting effects on the time and cost at the early stages of the project.

2. Literature review

In the many studies conducted on causes of time and cost overrun in projects, both locally and internationally have been reviewed. Most of the researchers focused on construction projects, and few studies have been done in oil, gas, and petrochemical projects and also very few research in Iran. Some of the previous studies were presented below:

Kaliba et al. identified the most important causes and effects of cost escalation and schedule delays in road construction projects in Zambia. They concluded that bad weather and heavy rains which lead to floods was the number one cause for cost escalation, also scope of work changes, environmental protection and mitigation costs, schedule delays, strikes, local government pressures, technical challenges, and inflation were found to be next major contributors to cost escalation [7].

Fallahnejad extracted 10 major delay factors in Iran gas pipeline projects by investigation 24 executive gas pipeline projects, according to the result, the five major factors are as follow: low ability of contractor to import material, unrealistic project durations imposed by owner, slow delivery of material by owner, slow land expropriation due to resistance from occupants, change orders, and extra works [8]. Sepehri analyzed the time delay factors in Iran and emerging countries. He studied the south pars gas project in Iran and founded that the most important

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causes of delay refer to planning phase [9]. Yang and Wei (2010) concluded that the most important cause of projects delay is "changes in owner's requirement" [10]. Lu et al. identified and analyzed the hidden transaction costs in project dispute resolutions. They identified the major variables of the hidden transaction costs and grouped them into five factors: reputation, cooperation/trust, emotion, time, and judgments. Based on the result, lack of future cooperation, contractors' reputation damage, and delayed recovery of money are the two most important variables, while for owners, project delay is the most severe hidden transaction cost [11]. Mansfield et al. studied the causes of time and cost overrun in Nigeria construction projects. Based on their research, the five main causes come from poor contract manager, financing and payment of completed works, changes in site conditions, shortage of materials, and improper materials and plant items [12]. A study to identify the factors influencing construction time and cost overruns on high-rise projects in Indonesia has been done by Kamin and Olomolaiye. Results of their study show that the main extra cost factors are raw materials costs, increase in inflation rate cost, inappropriate estimation of the required raw materials, and complexity of the project [13]. Assaf and Al-Hejji identified the causes of delays in construction in Eastern Province of Saudi Arabia. The results show that 70% of projects experience time overruns due to the various factors but the most common cause of delay identified by owner, consultant, and contractor is change order [14]. In building construction industry, based on Ahmed et al. research, consultants play a very important role in design-related delays and also delay in payments has effective impact on project completion times [15]. Sambasivan and Soon assessed the time over run in construction projects in Malaysia. The author presented ten most important causes of delay as follow: contractor's improper scheduling, poor site management, inadequate experience, delay in owner's finance and payments, problems with subcontractors, shortage in material, labor supply, failure of equipment, lack of communication between parties, and mistakes during the construction stage [16]. Faridi and El-Sayegh conducted a survey to evaluate the top-ten delay causes in the UAE construction industry, they point out that the major causes are related to preparation and approval of drawings, inadequate preplanning, and slow decision making by owners [17].

3. Methodology

In this study, five oil transmission pipeline projects, which have been executed by National Iranian Oil Company (NIOC) during 2000 to 2014, have been investigated. Based on project documents and also literature review, a comprehensive long list of cost overrun causes was prepared. The factors influenced cost overruns in projects were reviewed, modified, and finalized after semistructured interview and discussion by eight project team members who have more than 20 years' work experience, including one procurement manager from contractor, three project coordinators from owner, consultant and contractor, one contract engineer from consultant, and one financial manager from contractor. The final list of causes was reduced to 42 causes; these factors were categorized into five groups depending on their nature and mode of occurrence (See **Table 1**). Based on the final list that contained 42 cost overrun causes, a questionnaire was developed and sent to the respondents to evaluate the frequency of occurrence and severity of each identified causes.

Category	Factors
Client	KF01-Unrealistic time and cost estimation
	KF02-Delay in payments
	KT03-Poor feasibility study
	KT04-Change orders/extra work
	KT05-Incomplete design package during the tender
	KL06-Late land expropriation
	KP07-Delay in material delivering being client's obligation
	KP08-Slow decision making
	KP09-Change in management layer
	KH10-Lack of experts
	KC11-Ambiguity & conflict in contract
	KC12-Contract type
	KC13-Improper executive methods in contract
	KL14-Bidding method
	KL15-Slow speed in obtaining the permits/massive bureaucracy
	KR16-Poor coordination
	KR17-Poor communication
Contractor	PF01-Low technical capability/breakdown & shortage of equipment
	PF02-Delay in subcontractor's payment
	PF03-Propose unrealistic price to win the tender
	PF04-Contractor poor cash flow/financial problem
	PF05-Poor subcontractor performance
	PM06-Poor project management
	PM07-Project risk identifying
	PM08-Nonavailability of daily/weekly/monthly plan
	PM09-Weakness planning and scheduling
	PH10-HSE problems
	PH-11-Lack of expert labor/redundancy of works
	PH12-Change in material specification during the construction phase
Consultant	MT01-Weakness in design/slow in reviewing and approve the documents
	MM02-Poor supervision on schedule
	MM03-Delay in checking the contractor invoices
	MH04-Lack of skill on technical & contractual executive issues
	MH05-Poor management/lack of experts

Category	Factors
Vendor	VT01-Delay by vendors/suppliers
	VP02-Material shortage
External issues	SE01-Economic & political sanctions/low capability in procurement
	SE02-Rise in the price
	SE03-Weather condition/force majeure
	SE04-Change of government/priority of projects
	SE05-Inflation
	SE06-Change in low & regulations

Table 1. The factors influenced cost overruns in projects.

3.1. Questionnaire design and content validity

Four experts, whose characteristics are shown in **Table 2**, reviewed the preliminary questionnaire. The table shows extensive experience of the reviewer to modify and verify the questionnaire. Based on the result of the reviews, some modifications to general questionnaire format, text type, size, and wording of the paragraphs were suggested. Also some new items such as respondents' experience range and average of projects executed per year were added to the questionnaire. The questionnaire is divided into two sections: section I is related to general information about the companies, and section II includes the list of the identified causes of cost overrun. These causes are classified into five groups according to the source of problem: causes related to owner, contractor, consultant, and vendor/supplier and external issues. For each cause, two questions were asked: (1) what is the frequency of occurrence for this cause? and (2) what is the degree of severity of this cause on project cost overrun? Both parameters were scored on a five-point scale from 1 to 5; rating the factors with 1, representing the least condition, and 5, representing the highest condition (Likert Scale).

3.2. Research population

The population of the present research was categorized in three groups: the contractors, consultants, and owners in oil, gas, and petrochemical fields. The respondents of the owner were selected from the team members of four NIOC active projects. According to the Management

Position	Experience (years)	Organization
Assistant Professor	20	University
Chairman of the board/Engineering Manager	40	Consultants
Project Manager	36	Owner
Project Manager	30	Contractor
Procurement Manager	27	Contractor

Table 2. Characteristics of the questionnaire reviewed experts.

and Planning Organization of Iran (MPO), the contractor and consultant companies in Iran are classified into five and three classes, respectively, based on their performance in several fields: execution/experience record, company size, capital, assets, and qualifications of the technical staff. The authors considered contractors and consultant companies from class 1 (first class). The selected respondents for contractors were from among those companies being registered with the Association of Petroleum Industry Engineering and Construction companies (APEC), the consultant companies were those being members of the Iranian Society of Consulting Engineers and also both have cooperated with NIOC in pipeline projects. One hundred and seventy-five questionnaires were sent to the companies via email, fax, or post. One hundred and eleven questionnaires were returned by responses and after eliminating incomplete questionnaires; finally, 90 properly completed questionnaires were returned, yielding 51.4% responses. **Table 3** illustrates the statistic data of the questionnaire distribution and respondents' characteristics. The response rate for the questionnaire survey was 53.3%, 58.3%, and 47% for client, consultant, and contractor, respectively. As the response rate shows consultants had the maximum collaboration.

3.3. Ranking the causes

To calculate the ranking of cost overrun causes in terms of occurrence, severity, and importance from the view point of owner, consultant, and contractor, the method that was used by Le-Hoai et al. (2008), Alinaitwe et al. (2013), and Romuald-Kokou et al. (2013) has been followed [18–20]. The indices are obtained by the following formula:

Characteristics		**Organization**			
		Owner	**Consultant**	**Contractor**	**Total**
Sent	No.	15	60	100	175
	Percent	8.6%	34.3%	57.1%	100.0%
Received	No.	8	35	47	90
	Percent	8.9%	38.9%	52.2%	100.0%
Response rate	Percent	53.3%	58.3%	47.0%	51.4%
Gender	Male	15 (100%)	32 (91.4%)	100 (100%)	147 (98%)
	Female	0	3 (8.6%)	0	3 (2%)
Experience (years)	5–10	0	1 (2.9%)	7 (14.9%)	8 (8.9%)
	11–15	1 (12.5%)	8 (22.9%)	5 (10.6%)	14 (15.6%)
	16–20	2 (25.0%)	7 (20.0%)	18 (38.3%)	27 (30.0%)
	20+	5 (62.5%)	19 (54.3%)	17 (36.2%)	41 (45.6%)
Education	B.Sc.	6 (75.0%)	21 (60.0%)	41 (87.2%)	68 (75.6%)
	M.Sc.	1 (12.5%)	12 (34.3%)	4 (8.5%)	17 (18.9%)
	Ph.D	1 (12.5%)	2 (5.7%)	2 (4.3%)	5 (5.6%)

Table 3. Questionnaire statistics.

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Severity index is used to rank causes of cost overrun based on severity as indicated by the participants.

$$(\text{S.I.}) = \frac{\sum a_i s_i}{5N} (i \text{ from 1 to 5}) \quad (1)$$

a_i is the weight assigned to each response (ranges from 1 for not at all to 5 for extremely),

s_i is the severity of the impact,

N is the number of total respondents.

Severity index calculate through formula (1) for each factor and rank. The results are presented in **Table 4**.

Frequency index is used to rank causes of cost overrun based on frequency of occurrence as identified by the respondents.

$$(\text{F.I.}) = \frac{\sum a_i f_i}{5N} (i \text{ from 1 to 5}) \quad (2)$$

a_i is the weight assigned to each response (ranges from 1 for never to 5 for always),

f_i is the frequency of each response,

N is the number of total respondents.

Category	Factors	Client		Consultant		Contractor		Overall	
		S.I.	Rank	S.I.	Rank	S.I.	Rank	S.I.	Rank
Client	KF01	0.85	11	0.83	8	0.85	3	0.840	3
	KF02	0.78	18	0.84	6	0.91	1	0.87	2
	KT0	0.68	33	0.64	33	0.50	33	0.57	32
	KT04	0.75	23	0.74	22	0.74	15	0.74	16
	KT05	0.78	18	0.62	34	0.39	41	0.52	39
	KL06	0.80	15	0.69	29	0.77	10	0.74	17
	KP07	0.83	13	0.81	12	0.74	13	0.78	13
	KP08	0.80	15	0.79	14	0.70	20	0.74	14
	KP09	0.58	41	0.61	36	0.46	37	0.53	38
	KH10	0.70	32	0.69	28	0.57	29	0.63	28
	KC11	0.65	35	0.59	38	0.42	40	0.50	41
	KC12	0.73	28	0.57	40	0.49	35	0.54	36
	KC13	0.73	28	0.58	39	0.43	38	0.52	39
	KL14	0.90	4	0.85	5	0.75	11	0.80	9
	KL15	0.80	15	0.72	25	0.72	18	0.73	18
	KR16	0.65	35	0.71	26	0.73	17	0.72	20
	KR17	0.75	23	0.66	32	0.73	16	0.70	24

Category	Factors	Client		Consultant		Contractor		Overall	
		S.I.	Rank	S.I.	Rank	S.I.	Rank	S.I.	Rank
Contractor	PF01	0.90	4	0.79	15	0.68	21	0.74	15
	PF02	0.88	7	0.83	7	0.81	5	0.83	6
	PF03	0.93	2	0.86	3	0.81	6	0.838	5
	PF04	0.88	7	0.82	10	0.80	7	0.82	8
	PF05	0.73	28	0.76	19	0.66	23	0.71	23
	PM06	0.93	2	0.82	9	0.84	4	0.84	3
	PM07	0.58	41	0.71	27	0.43	39	0.55	35
	PM08	0.90	4	0.75	20	0.65	24	0.71	22
	PM09	0.75	23	0.78	16	0.58	27	0.67	26
	PH10	0.78	18	0.55	41	0.47	36	0.53	37
	PH-11	0.88	7	0.81	11	0.75	12	0.78	11
	PH12	0.65	35	0.67	31	0.59	26	0.63	28
Consultant	MT01	0.78	18	0.77	18	0.63	25	0.70	25
	MM02	0.85	11	0.74	23	0.57	28	0.66	27
	MM03	0.75	23	0.68	30	0.51	32	0.60	31
	MH04	0.75	23	0.73	24	0.71	19	0.72	19
	MH05	0.68	33	0.77	17	0.68	22	0.71	21
Vendor	VT01	0.78	18	0.80	13	0.77	9	0.78	12
	VP02	0.73	28	0.75	21	0.50	34	0.62	30
External issues	SE01	0.95	1	0.91	1	0.86	2	0.88	1
	SE02	0.88	7	0.85	4	0.79	8	0.82	7
	SE03	0.65	35	0.52	42	0.34	42	0.44	42
	SE04	0.63	39	0.62	35	0.51	31	0.56	33
	SE05	0.83	13	0.86	2	0.74	14	0.80	10
	SE06	0.60	40	0.60	37	0.53	30	0.56	33

Table 4. Severity index of cost overrun causes in oil transmission pipeline projects in Iran (S.I. and ranking).

Based on the above formula frequency index and rank of each factor has been calculated. **Table 5** shows the results.

Importance index calculated as a function of both frequency and severity indices to evaluate the ranking of each cause with respect to its impact on cost overrun from viewpoints of the three parties (client, contractor, and consultant).

$$(\text{IMP.I.}) = (\text{F.I.}) \times (\text{S.I.}) \tag{3}$$

The indices were calculated and ranked through the formulae (1)–(3), and the results are illustrated in **Table 6**.

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Category	Factors	Client		Consultant		Contractor		Overall	
		F.I.	Rank	F.I.	Rank	F.I.	Rank	F.I.	Rank
Client	KF01	0.43	34	0.75	12	0.73	11	0.71	12
	KF02	0.65	20	0.63	16	0.92	2	0.78	8
	KT0	0.53	29	0.51	24	0.53	30	0.52	30
	KT04	0.75	13	0.77	11	0.94	1	0.86	2
	KT05	0.35	40	0.37	42	0.50	32	0.44	38
	KL06	0.58	23	0.53	23	0.71	13	0.63	21
	KP07	0.58	23	0.46	33	0.66	16	0.58	22
	KP08	0.73	15	0.60	18	0.83	5	0.73	10
	KP09	0.40	37	0.38	41	0.42	38	0.40	42
	KH10	0.30	42	0.43	37	0.63	20	0.52	29
	KC11	0.45	33	0.54	22	0.41	39	0.46	36
	KC12	0.65	20	0.41	39	0.48	34	0.47	35
	KC13	0.40	37	0.45	35	0.50	33	0.47	34
	KL14	0.85	6	0.87	3	0.70	15	0.78	9
	KL15	0.93	1	0.85	4	0.80	9	0.83	4
	KR16	0.55	27	0.58	19	0.74	10	0.66	18
	KR17	0.48	31	0.55	21	0.61	24	0.58	22
Contractor	PF01	0.73	15	0.43	38	0.48	35	0.48	33
	PF02	0.700	17	0.82	10	0.62	23	0.70	15
	PF03	0.90	4	0.93	1	0.71	14	0.81	6
	PF04	0.750	13	0.65	15	0.66	17	0.66	19
	PF05	0.93	1	0.84	6	0.62	22	0.73	10
	PM06	0.70	17	0.49	29	0.55	29	0.54	28
	PM07	0.90	4	0.83	7	0.57	27	0.70	14
	PM08	0.78	11	0.83	8	0.56	28	0.68	16
	PM09	0.65	20	0.71	14	0.63	19	0.67	17
	PH10	0.55	27	0.44	36	0.41	40	0.43	39
	PH-11	0.68	19	0.47	31	0.59	26	0.55	26
	PH12	0.85	6	0.55	20	0.80	8	0.71	12
Consultant	MT01	0.80	9	0.51	25	0.73	12	0.65	20
	MM02	0.53	29	0.48	30	0.65	18	0.57	24
	MM03	0.38	39	0.47	32	0.52	31	0.49	32
	MH04	0.58	23	0.50	26	0.63	21	0.57	24
	MH05	0.48	31	0.50	27	0.60	25	0.55	27

Category	Factors	Client		Consultant		Contractor		Overall	
		F.I.	Rank	F.I.	Rank	F.I.	Rank	F.I.	Rank
Vendor	VT01	0.83	8	0.74	13	0.82	6	0.79	7
	VP02	0.43	34	0.62	17	0.43	37	0.50	31
External issues	SE01	0.93	1	0.89	2	0.84	4	0.86	1
	SE02	0.78	11	0.82	9	0.88	3	0.85	3
	SE03	0.35	40	0.46	34	0.40	41	0.42	41
	SE04	0.58	23	0.49	28	0.38	42	0.44	37
	SE05	0.80	9	0.85	5	0.81	7	0.82	5
	SE06	0.43	34	0.38	40	0.45	36	0.42	40

Table 5. Frequency index of cost overrun causes in oil transmission pipeline projects in Iran (F.I. and ranking).

Category	Factors	Client		Consultant		Contractor		Overall	
		IMP	Rank	IMP.I.	Rank	IMP.I.	Rank	IMP	Rank
Client	KF01	0.88	1	0.80	1	0.80	2	0.76	1
	KF02	0.68	6	0.70	5	0.69	4	0.70	2
	KT0	0.50	20	0.53	16	0.83	1	0.68	3
	KT04	0.83	2	0.80	2	0.57	10	0.68	4
	KT05	0.66	8	0.73	4	0.60	7	0.65	5
	KL06	0.56	17	0.57	13	0.70	3	0.64	6
	KP07	0.77	3	0.73	3	0.53	13	0.63	7
	KP08	12	0.47	0.59	11	0.63	5	0.62	8
	KP09	0.74	4	0.61	10	0.58	9	0.60	9
	KH10	0.36	28	0.62	9	0.62	6	0.60	10
	KC11	0.61	14	0.68	6	0.50	15	0.58	11
	KC12	0.58	16	0.48	17	0.58	8	0.55	12
	KC13	0.66	9	0.53	15	0.53	14	0.54	13
	KL14	0.67	7	0.64	7	0.41	23	0.52	14
	KL15	0.70	5	0.62	8	0.36	27	0.49	15
	KR16	0.36	30	0.42	19	0.54	12	0.48	16
	KR17	0.46	24	0.36	27	0.55	11	0.47	17

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Category	Factors	Client		Consultant		Contractor		Overall	
		IMP	Rank	IMP.I.	Rank	IMP.I.	Rank	IMP	Rank
Contractor	PF01	0.65	11	0.40	20	0.46	18	0.45	18
	PF02	0.62	13	0.39	21	0.46	19	0.45	19
	PF03	0.49	21	0.56	14	0.37	26	0.45	20
	PF04	0.55	18	0.37	24	0.48	17	0.45	21
	PF05	0.47	22	0.37	25	0.49	16	0.45	22
	PM06	0.59	15	0.38	22	0.44	22	0.43	23
	PM07	0.43	26	0.37	26	0.45	21	0.42	24
	PM08	0.36	31	0.36	28	0.45	20	0.41	25
	PM09	0.32	33	0.38	23	0.40	24	0.39	26
	PH10	0.52	19	0.59	12	0.24	32	0.39	27
	PH-11	0.45	25	0.56	14	0.37	25	0.38	28
	PH12	0.65	10	0.34	30	0.32	29	0.36	29
Consultant	MT01	0.21	42	0.30	35	0.36	28	0.33	30
	MM02	0.31	34	0.46	18	0.21	36	0.31	31
	MM03	0.35	32	0.33	31	0.26	31	0.30	32
	MH04	0.28	37	0.32	32	0.27	30	0.29	33
	MH05	0.47	23	0.23	42	0.23	34	0.25	34
Vendor	VT01	0.36	29	0.30	34	0.20	38	0.25	35
	VP02	0.29	36	0.26	36	0.21	35	0.24	36
External issues	SE01	0.26	39	0.23	41	0.24	33	0.24	37
	SE02	0.29	35	0.32	33	0.17	41	0.23	38
	SE03	0.43	27	0.24	37	0.19	39	0.23	39
	SE04	0.27	38	0.23	39	0.20	37	0.23	40
	SE05	0.23	40	0.23	40	0.19	40	0.21	41
	SE06	0.23	41	0.24	38	0.13	42	0.18	42

Table 6. Importance index of cost overrun causes in oil transmission pipeline projects in Iran (IMP.I. and ranking).

3.4. Spearman's rank correlation

There are two types of correlation test: parametric and nonparametric. In this research, Spearman's correlation test, which is a nonparametric test, is used to measure the correlation between two parties ranking. Nonparametric tests are referred to as distribution free tests.

These tests have the obvious advantage of requiring neither the assumption of normality nor the assumption of homogeneity of variance. The formula No. (4) represents the Spearman's rank Correlation Coefficient:

$$r_s = 1 - \frac{6\sum d^2}{N(N^2 - 1)} \tag{4}$$

r_s is Spearman's rank correlation coefficient between two parties,

d is the difference in ranking between two parties,

N is the number of variables (here 42).

4. Results and discussion

4.1. Analysis of results

By using the formula No. (1), (2) and (3), the frequency, severity and importance indices were calculated, and the results are presented in **Tables 4–6**, respectively. The final ranking of factors' importance from all parties' point of view is presented in **Table 6**. From statistical analysis, it was found that the political and economic sanctions (low capability of parties in supply the materials/equipment), rise in the price of materials, delay in payments, propose the unrealistic price with the aim of winning the tender, inflation, change orders/extra works, type of bidding award, delay by vendors/suppliers, slow speed in obtaining permits/massive bureaucracy, and unrealistic time and cost estimation are ranked in the top 10 cost overrun factors (**Figure 1**).

According to the results, the average of each group factors importance index (IMP.I.) represents the group ranking, and as a result, the ranking of all five groups is as follow: (1) external issues, (2) vendor/suppliers, (3) contractor, (4) client, and (5) consultant. It means that in the current condition in Iran, external issue–related problems have great degree of importance on cost overrun and most of these problems are uncontrollable; therefore, they could be surprisingly considered as the most significant origin of cost overrun in oil pipeline projects in Iran. The Spearman's correlation coefficients of the ranking have been calculated, and the results are presented in **Table 7**. The calculated data indicate that the important perception of the variables between the three groups (client, consultants, and contractor) is in acceptable agreement. The highest degree of agreement is between clients and consultants (0.806) while the lowest is between clients and contractors (0.657).

4.2. Comparison and discussion

The top five important cost overrun causes in eight projects are listed in **Table 8**. The results of current research are also added to the table for comparison and discussion. Based on the results, external issues–related problems have high significant effect on cost overrun and ranked at the top place. Also they are common in all the reviewed researches but differ in ranking. External issue is a main category and is divided into sub-groups. In this research, political and economic sanctions related problems are first in factor ranking. Generally in

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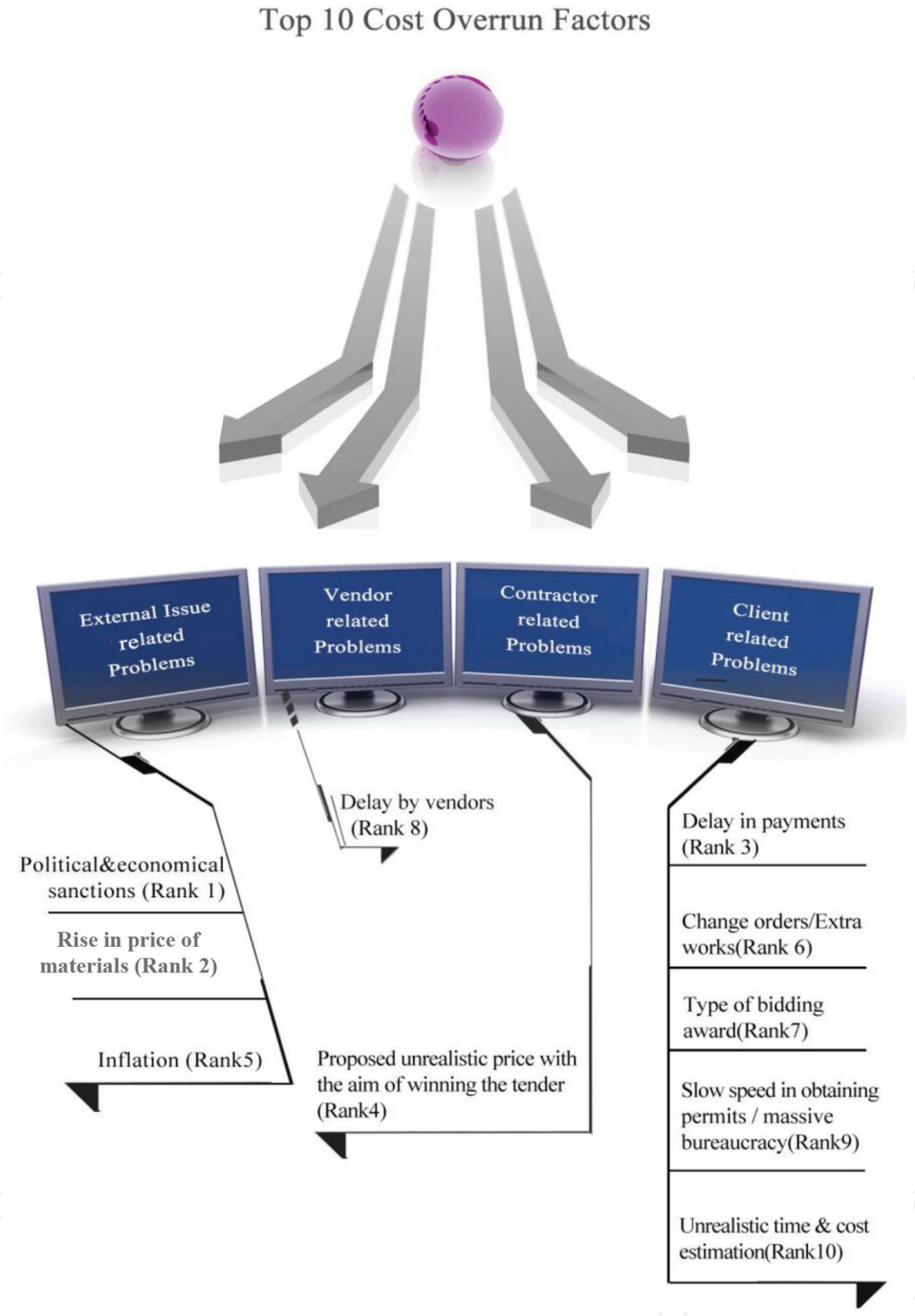

Figure 1. Ten major causes of cost overrun in oil transmission pipeline projects in Iran.

Organization	Correlation coefficient	Sig. (2-tailed)	No. of factors
Client-consultant	0.806	0.000	42
Client-contractor	0.657	0.000	42
Consultant-contractor	0.754	0.000	42

Table 7. Spearman correlation coefficient.

Reference no.	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
[12]	Poor contract management	Financing & payment of completed works	Changes in site conditions	Shortages of materials	Imported materials & plant items
[22]	Late payment	Poor cash flow, management	Insufficient financial resources	Financial market instability	—
[23]	Material problems	Financial problems	Organization deficiencies	Lack of qualified workers	Extra works
[21]	External risks	Inadequate financial strength (client)	Inadequate financial strength (contractor)	Failure in performing contractor's obligations	Dispute regarding contract interpretation
[8]	Low ability of contractor to provide imported material	Unrealistic contract durations imposed by client	Slow delivery of material	Slow land expropriation	Change orders
[7]	Bad weather	Inflation	Schedule delay	Scope changes	Local government pressures
[24]	Monthly payment difficulties	Poor contract management	Material procurement	Inflation	Contractor's financial difficulties
[25]	Unclear scope of work, cost control	Contract dispute	Fluctuation, the gap between plan and actual, material shortage	Time management	Practical experience
This study	Sanctions	Rise in the prices	Delay in payments	Propose the unrealistic price to win the tender	Inflation

Table 8. Comparison of the top five major time/cost overrun factors from literature reviewed.

Iran's oil, gas, and petrochemical projects, more than 70% of the whole project's weight is related to procurement phase, and due to the low ability of project's parties to purchase and import the materials/equipment, most of the projects are behind the schedule and have delay in project deliverables as well which leads to cost overrun. Fallahnejad and Hasheminasab et al., both presented the same problem for projects in Iran in their researches [8, 21]. But in the other researches related to other countries, the external issue problems are such bad weather, site condition, or government pressure, and none of them addressed to this factor in the series of the top 10 important causes. The other effects of sanctions are also noticeable and cannot be ignored. It can primarily be categorized as (a) refusal of reputable foreign companies to come or continue working in Iran and consequently slowing down the pace of transfer of knowledge of new construction methods and management, (b) lack of opportunities for ambitious and qualified managers which encourage them to leave Iran for opportunities in other countries (brain drain), (c) lack of chance for young graduates to train for up to date methods of construction which leading to lack of experts, and (d) lack of modern construction equipment which were prevented due to sanctions to bring in to Iran.

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Rise in the price of materials and inflation are the factors, which are addressed by five researchers from **Table 8**. Their ranking in current study is second and fifth, respectively. Unfortunately, the duration of oil pipeline project is quite long and due to the special economic and political condition in Iran, the cost overrun due to these problems is predictable for the projects. It should be noted that these factors are uncontrollable but consideration and identification them at early stages of the project would help project's participants to issue effective plan in case of occurrence.

Other material-related problems such as material monopoly by some vendors/suppliers and vendors delay in delivery of material are also common in most of the projects in different countries regardless of political, economic culture, and social conditions, that implementing an efficient quality control and assurance system by the third party and periodical vendors/suppliers assessment would be useful to mitigate negative impacts.

Client-related problems such as late payment, change orders/extra work, low speed in decision making, slow speed in obtaining the permits, type of bidding, and client cash flow are addressed in all the seven researches. According to the result of this study, the position of delay in payment factor is three in the series of top ten important factors. Due to the delay in payments, most of the projects are now delayed, so the project duration increased, and as a result, the cost escalated. The client, NIOC, is one of the major subsidiaries of the Ministry of Petroleum of Iran, has powerful financial background but the delay in payment problem could be the result of excessive bureaucracy in the government organization in Iran, especially in their financial management department due to their complex and time consuming financial processes. Project manager should prepare a financial plan and also assign required budget for the project before entering to the execution phase, this would allow client to ensure that required budget during the execution of project is available. It can be concluded the main source of this problem come from mismanagement of the project. Cooperation and investment of private sectors would be one of the solutions as well. Spending adequate time for feasibility study and preparing a complete and clear contract documents would decrease the quantity of change orders as well.

Contractor financial problem during the execution of projects is one of the major problems leading to time and cost overrun effectively. In Iran the source of this problem may come back to the uncompetitive bidding type. The process of evaluation of the proposals in Iran is of two stages, technical and financial evaluation, but due to the low impact of the quality criteria in final evaluation, proposed price would be the governing factor. Some contractors proposed unrealistic price just to win the tender. Not only this is not a fair competition (capable contractors will lose the chance of winning) but also the projects failing to meet budgetary, schedule, and desire quality because the potentially more qualified contractors who have followed the professional ethics in their proposal are not able to be awarded the contract. The source of this problem is not unprofessional or incomplete cost estimates. It is the contractor strategy to award the tender and after that they may try to find a way to compensate their financial deficit such as claims. Claims are always time consuming and leading cost overrun and delay in target completion date; therefore, in case of occurrence, this problem, the prompt reaction and sensitivity of clients on project duration, is necessary. On the other hand, as this kind of delay, as a result of claim, is

not an excusable delay, client should terminate the contract as per the contract's related clauses and retender the contract. But because of the very difficult and complex law, regulation and processes related to retender the contracts, clients in Iran are unlikely to terminate the contracts, and contractors are aware of this issue. Revising the bidding and contractor selection methods and also reviewing the termination laws would be useful to reduce probability of raising such a problem. In spite of the high rank of this factor (4th place) in the current research, it has low impact on cost overrun in the other researches reviewed by the authors.

5. Conclusion

According to the 20-year Vision Plan of Iran's oil industry, Iran mission is to increase the oil production capacity over 12% of the world's oil production by the end of the 2025, which needs to develop the existing projects and also define several new projects as well. Reviewing the existing documents for oil pipeline projects in Iran shows that these kinds of projects are facing time and cost overrun. Therefore, identification of the time and cost overrun factors is one of the most important activities to achieve the Vision Plan's goals. In the current research based on the previous project documents and also literature review, a list of 42 cost overrun causes was prepared. The top 10 causes then identified through a questionnaire survey which are as political and economic sanctions (low capability of parties in supply the materials/equipment), rise in the price of materials, delay in payments by client, propose the unrealistic price with the aim of winning the tender by contractor, inflation, change orders/extra works by client, type of bidding award by client, delay by vendors/suppliers, slow speed in obtaining permits/massive bureaucracy, and unrealistic time and cost estimation by client. Based on the responses, factors related to political condition in Iran are the major factors affecting cost overrun and, at the same time, are the most common factors. The results of this research could help participants of Iranian oil industry to have the strategic plan before getting involved in the projects. Future investigations could be done to identify the source of these causes and propose solutions to mitigate the negative impacts.

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